THE JOURNAL OF
EDUCATIONAL PSYCHOLOGY

Volume 39 December, 1948 Number 8

DIRECT ROTATION TO PRIMARY STRUCTURE

CHESTER W. HARRIS

The University of Wisconsin

Certain relationships between the simple-axis and the primary-axis solution in factor analysis were discussed in an earlier paper.[1] As a result of considering these relationships, a procedure for the rotation of orthogonal centroids directly to primary structure was formulated and its applicability tested. Preliminary results are encouraging enough to warrant presenting a description of the method so that other students may have access to the procedure and may provide additional tests of its applicability. It would be foolhardy to claim in advance that this new procedure necessarily must work with all problems. As Thurstone has pointed out, "It must not be forgotten that it is an open question for each factorial study whether any simple structure exists at all or whether any one or several hyperplanes can be defined."[2] Since the simple structure and the primary structure are related, the statement is equally true for the question of whether or not primary structure exists for a particular problem. Similarly, it would be folly to attempt to shrug off any failures of the method by attributing them solely to the inappropriateness of the design of the factorial study. What is needed is knowledge of the situations in which the method works, and of those in which it does not. Its degree of objectivity and of generality can then, in time, be estimated.

The simple axes are defined as the normals to coördinate planes,[3] in each of which lie a number of the variables. If the

[1] Chester W. Harris and Dorothy M. Knoell, "The Oblique Solution in Factor Analysis," *Jour. Ed. Psycho.* Vol. 39, Nov., 1948, pp. 385–403.

[2] L. L. Thurstone, *Multiple-Factor Analysis*, Chicago: University of Chicago Press, 1947, p. 340.

[3] For convenience, the term 'plane' is used throughout, with the recognition that 'hyperplane' may be meant.

problem is a 'neat' one, all the variables will lie within these planes. If all the variables are of complexity one, then they all must lie at the intersections of these planes. The intersections of these planes define the primary axes. Thus, this concept of simple and primary axes has implicit in it the several relationships pointed out in the previous article.[1] There it was also pointed out that in a three-dimensional problem in which the variables all are of complexity one, the extended vector representation permits the determination of the direction cosines for either the simple axes or for the primary axes. With such an ideal problem, only one rotation is necessary to secure either the simple structure or the primary structure. This ideal problem suggested the possibility that the principle of a single rotation directly to primary structure might be applied more generally. The method that has been outlined is, briefly, that of identifying the points defined by the intersection of the planes and taking their direction numbers as a basis for the transformation matrix of direction cosines. In so doing, one takes the primary axes as the reference axes.

Because the ideal three-dimensional problem presents such an obvious 'answer,' it seemed desirable to apply the method to problems that involve more than three factors and problems that include variables of complexity greater than one. In order to illustrate the method, and to present preliminary evidence of its applicability, three problems were chosen. Two of these are problems for which Thurstone has presented a simple-axis solution in his text. These will be taken as illustrations first, so that the reader may satisfy himself of the comparability of the two types of solution. As a final illustration, a nineteen-variable problem that is currently being analyzed in a study of students' preferences for literary passages has been taken. The application of the method to a problem for which no known solution existed *a priori* can thus be presented.

A FIVE-DIMENSIONAL FICTITIOUS PROBLEM

The first illustration is Thurstone's five-dimensional fictitious problem that he offers as an example of the use of extended vector

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[1] Harris and Knoell, *op. cit.*

diagrams in rotating to simple structure.[1] This is a special problem, in one sense, since the fictitious configuration is taken to be orthogonal. When such is the case, the primary and the simple solutions should be identical, with identical structure and pattern values for each solution. Thus the expectation would be that the method of direct rotation to primary structure would give a set of values identical with the simple-structure values secured by Thurstone by his rotation system. Actually, the single rotation to primary structure does not reproduce Thurstone's rotated solution exactly; instead, it reproduces the fictitious configuration which Thurstone's solution approximates, exact to two decimal places. For this problem, the direct rotation to primary structure gives a more precise solution than did Thurstone's procedure.

If the reader will refer to Thurstone's text he will note that the centroids to be rotated are given on page 231. The extended vector values for these variables are also given, and four of the six extended-vector diagrams are reproduced (pages 232–36). The problem is to locate the points to which the primary axes are extended. If projected variables coincide with these points, then these variables must lie at the intersections of the planes that define the primary axes. The planes themselves, according to the definition, must pass through a number of the variables; i.e., many of the variables must lie within these planes. Further, if the configuration has only positive simple-structure values, then the representation of these planes on the extended-vector diagrams should be in the form of boundary lines. For Figure 3, page 233, these planes can be represented by lines joining variables 19 and 13, 13 and 21, 21 and 2, 2 and 19. On Figure 5, page 235, they can be represented by lines joining variables 13 and 7, 7 and 2, 2 and 21, 21 and 13. On Figure 6, page 236, only three boundary lines appear; these join variables 19 and 7, 7 and 13, 13 and 19.

On Figure 4, page 234, variable 9 presents something of a problem. One possibility is that it marks an intersection. If it does, then the bounding lines on this plot would give a five-sided figure. Present experience with the method suggests that four should be the maximum number of sides for the figure formed by the bounding lines. Possibly a student who is more sophisticated

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[1] Thurstone, *op. cit.*, pp. 230–58.

with respect to the geometry of hyperspace will be able to demonstrate this as a necessary condition. At present, this condition is an outgrowth of empirical observation for several different kinds of problems, and as such it must be accepted quite tentatively. A more forceful objection to taking 9 as marking an intersection is its position on the other plots. On each of the other three (and on the two additional plots that Thurstone does not reproduce) variable 9 clearly lies on a line between 7 and 21, and on none of them does it lie outside the boundary lines already designated. Since it does not consistently mark a possible intersecting point, it can be regarded as a complex variable that on this one plot has been extended outside the boundary.

In attempting to locate primary axes, the criterion of consistency appears to be the most compelling one. It is the consistency of the appearance of the same variables at the 'corners' of boundaries that leads to the selection of variables number 19, 2, 7, 21, and 13 as marking the extensions of the primary axes. (The reader may wish to prepare the two additional diagrams that Thurstone omits and satisfy himself that these variables also mark the corners on these plots.)

Once the extended variables that are taken as locating the extensions of the primary axes have been determined, the next step is to write their direction numbers. Either the centroid loadings or the extended-vector values of the variable may be taken as the direction numbers of the primary axis that is located by that extended variable. Thus, for Thurstone's problem, these direction numbers were taken from his table of extended-vector values:

	P_1 (19)	P_2 (2)	P_3 (7)	P_4 (21)	P_5 (13)
I	1.00	1.00	1.00	1.00	1.00
II	−.33	1.33	−.96	1.24	−.90
III	−.21	1.46	−.84	−1.24	.90
IV	−1.86	−.21	.28	.69	.90
V	−.63	1.03	1.51	−.69	−.90

These direction numbers were normalized to give a matrix of direction cosines that transforms the centroid factor matrix into the primary structure matrix. This transformation matrix was found to be:

	P_1	P_2	P_3	P_4	P_5
I	.447	.408	.448	.446	.486
II	−.148	.543	−.430	.553	−.437
III	−.094	.596	−.376	−.553	.437
IV	−.831	−.086	.125	.308	.437
V	−.282	.420	.676	−.308	−.437

This transformation matrix is approximately the same as Thurstone's M_{04}, which is given on page 252. When the centroid factor matrix is post-multiplied by it, the fictitious configuration is reproduced, exact to two decimal places. This is a somewhat closer reproduction than is given by Thurstone's four sets of rotations. That this exact reproduction should take place is evident from comparing the transformation matrix developed by the new method with the arbitrary transformation Thurstone used to secure the centroids for illustration. One is the transpose of the other.

It was pointed out that the fictitious configuration was taken as orthogonal, and that consequently the primary and the simple solutions are identical, with identical values for structure and pattern. Since the configuration was taken as orthogonal, the correlations between primary axes that are located by the new method should be found to be zero. Pre-multiplying its transpose by the matrix of direction cosines developed by this method demonstrates their orthogonality. The reader may be interested in noting that this orthogonality is suggested by the fact that the diagonals of the quadrilateral figures on the extended-vector diagrams intersect at right angles. This reproduction of the fictitious simple configuration is a function of the orthogonality of the configuration. Had the simple configuration been taken as correlated, then the simple-axis and the primary-axis solutions would not have been identical. Consequently, direct rotation to primary structure would not have given the values Thurstone secures by his method. This will be illustrated by the second problem.

The major value of this example has been the illustration of the possible economy of the new method. Four sets of rotations, which include the making of new diagrams and the necessary matrix multiplications, were used to secure the solution by the conventional method. The new method required only the

original set of extended-vector diagrams and the one rotation. This is a considerable saving in the time required to secure an interpretable solution. In addition, this example illustrates the possible precision of the method, since the single rotation reproduced the fictitious configuration with considerable exactness. Finally, the example has indicated that the method is applicable when variables of complexity greater than one are included, and when the special case of orthogonal primaries is met with.

THE TRAPEZOID PROBLEM

Thurstone's trapezoid problem was taken as a second illustration.[1] He presents the orthogonal centroids and a rotated simple structure that is oblique. Extended-vector values were computed and the diagrams prepared. These are given as Figure 1. In preparing these diagrams, variables 14, 15, and 16 were not plotted. Variables 15 and 16 have negative values on the first centroid. (See page 432.) It does not appear to be meaningful to plot such variables in extended-vector form. Variable 14 also was omitted, since it has a very low value on the first centroid. The effect of this low value, in the extended-vector representation, is to place it at a great distance from the origin and from the main concentration of points in the plots. This omission of these three variables in the plotting amounts to a choice which establishes the reference frame with respect to the thirteen variables that have substantial positive projections on the first centroid. It should be noted that although this is an arbitrary choice, it is not an unprecedented one. For example, in solving the box problem, Thurstone makes a similar choice when he omits variables 13 through 18 from his extended-vector diagram.[2]

In Figure 1, lines representing planes have been drawn to join what appear to be the 'corners' of the figures. One is a quadrilateral figure, and the other two are triangles. This has been a fairly consistent finding for four-dimensional problems. The quadrilateral has variables 1, 2, 3, and 4 as its corners. These variables also form the corners of the two triangles. Thus, their consistent appearance at intersections of the planes suggests taking them as marking the extensions of the primary axes.

The position of variable 11 should be noted. It lies outside the

[1] Thurstone, *op. cit.*, pp. 427–34.

[2] *Ibid.*, pp. 371–75.

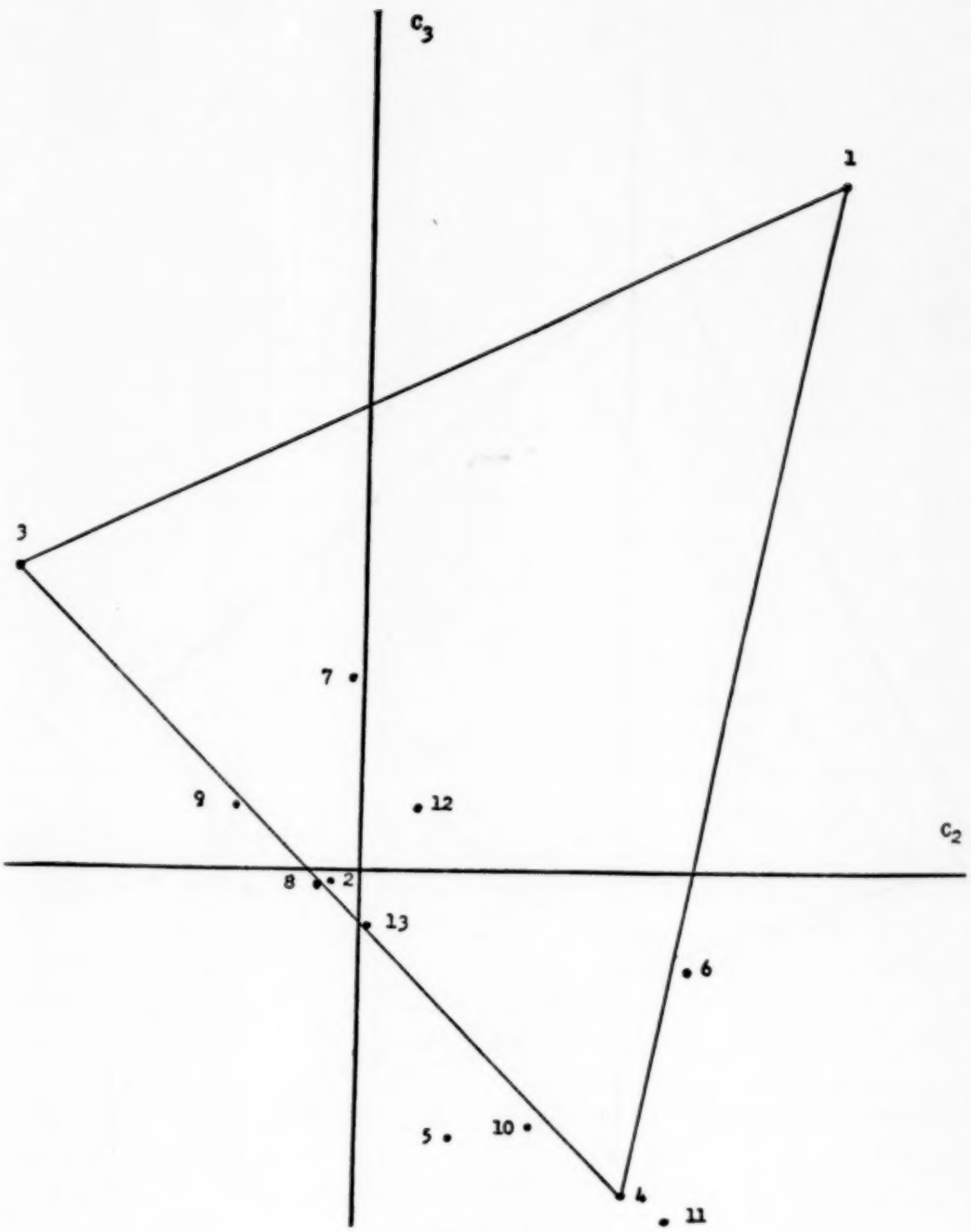

Fig. 1a.

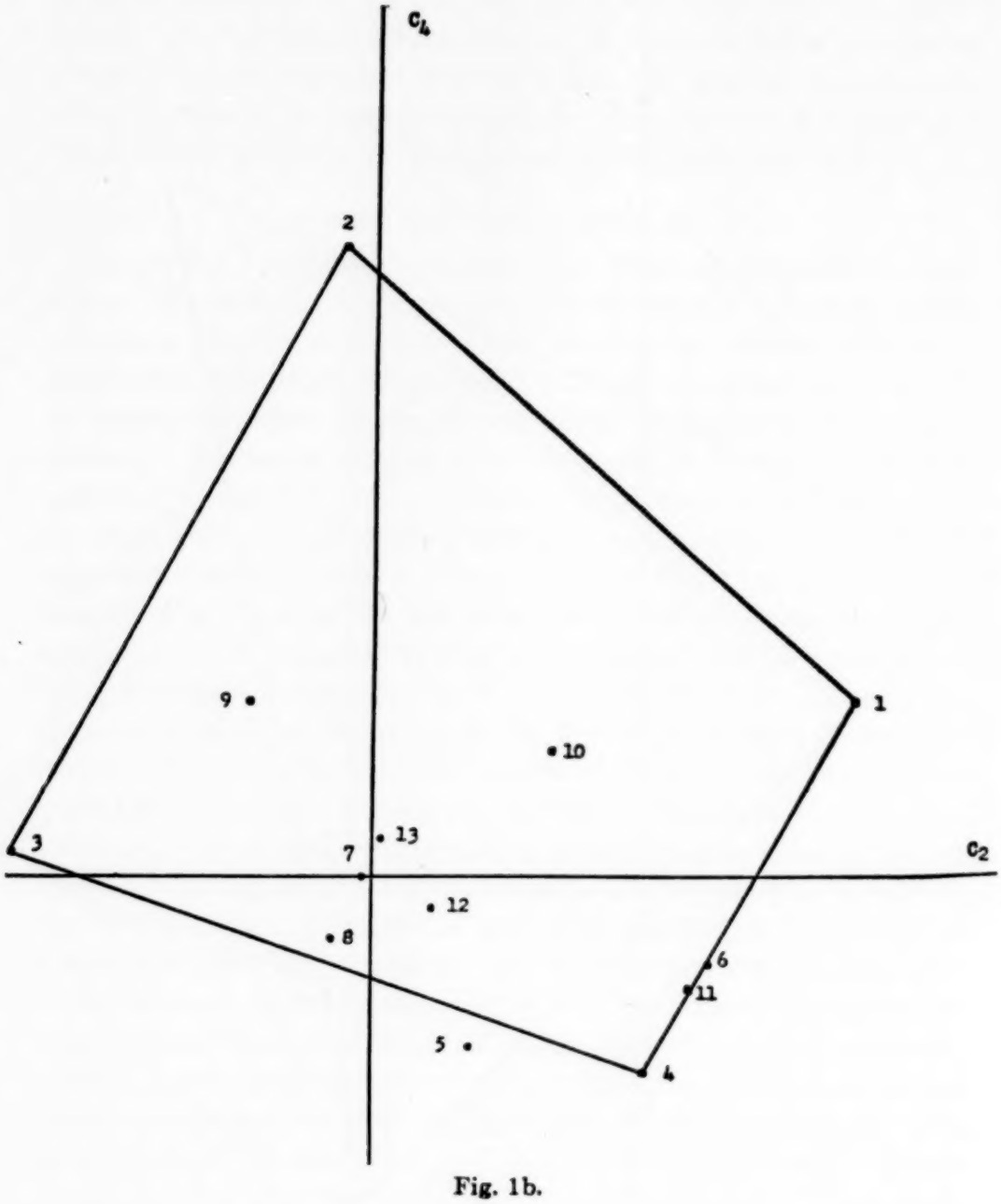

Fig. 1b.

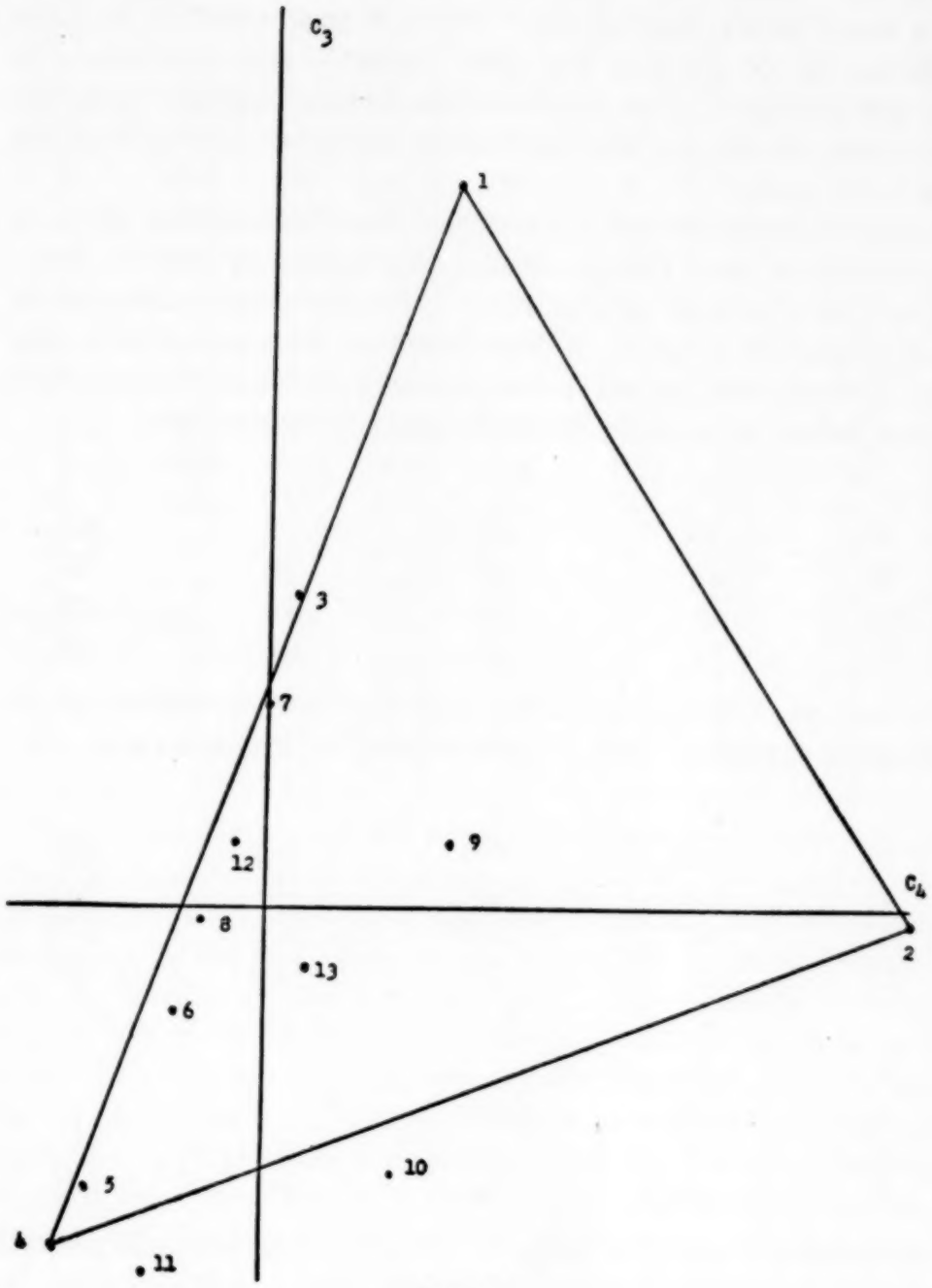

Fig. 1c.

boundary line on the plot of C_3 and C_4. To have taken it as a corner, however, would have placed a large number of the other variables outside the boundary. For this reason, 4 appears to be a more satisfactory choice. The fact that 4 and 11 lie close together on all three of the plots indicates that this choice is not a crucial one. The two variables lie close together in space, and the extension of either one of them might be taken as marking a primary axis.

Once the variables 1, 2, 3, and 4 have been identified as marking the intersections of the boundaries, it is necessary only to determine their direction numbers and normalize these to secure the transformation matrix. These direction numbers, taken this time from the orthogonal factor matrix rather than the extended-vector values in order to illustrate this alternative, are:

	P_1	P_2	P_3	P_4
I	.57	.59	.79	.81
II	.44	−.03	−.46	.35
III	.63	−.01	.38	−.42
IV	.16	.59	.03	−.25

The matrix of direction cosines, and the intercorrelations of the primaries computed from this matrix and its transpose are:

	P_1	P_2	P_3	P_4
I	.588	.707	.798	.803
II	.454	−.036	−.464	.347
III	.650	−.012	.384	−.416
IV	.165	.707	.030	−.248

	P_1	P_2	P_3	P_4
P_1	1.00			
P_2	.51	1.00		
P_3	.51	.60	1.00	
P_4	.32	.38	.31	1.00

The solution is given in Table 1. The first four columns give the primary structure values. These are the correlations of the variables with the primary axes. The next four columns give the primary pattern values. These are the coördinates of the variables with respect to the primary reference axes.[1]

[1] For a method of computing pattern values from structure values see: Karl J. Holzinger and Harry H. Harman, *Factor Analysis*. Chicago: University of Chicago Press, 1941, pp. 386–89.

TABLE 1.—PRIMARY SOLUTION

Variable	Structure				Pattern			
	r_{jP_1}	r_{jP_2}	r_{jP_3}	r_{jP_4}	P_1	P_2	P_3	P_4
1	.971	.488	.497	.309	.97	−.01	.00	.00
2	.424	.835	.499	.321	.00	.84	.00	.00
3	.508	.592	.991	.309	.00	.00	.99	.00
4	.321	.388	.315	1.000	.00	.00	.00	1.01
5	.290	.452	.489	.969	−.15	.01	.27	.93
6	.610	.515	.423	.946	.34	.04	−.04	.83
7	.750	.676	.891	.639	.32	.02	.61	.34
8	.515	.625	.804	.796	.00	.04	.59	.60
9	.582	.868	.893	.588	−.02	.43	.59	.24
10	.425	.738	.453	.901	−.04	.51	−.06	.74
11	.327	.444	.268	.979	.01	.14	−.12	.96
12	.668	.646	.769	.781	.24	.05	.44	.55
13	.532	.736	.745	.813	.01	.27	.40	.58
14	.697	−.145	.188	.156	1.00	−.74	.09	.10
15	−.351	−.175	−.869	−.217	−.01	.56	−1.18	−.06
16	.105	−.297	−.714	−.130	.64	.00	−1.04	−.01

The intercorrelations of the primaries given above approximate the intercorrelations of the primaries given by Thurstone for this problem.[1] That essentially the same primary axes have been identified by the two methods is indicated by the relatively close correspondence of the two matrices. The primary structure values, given in Table 1, may appear strange at first view. Since the reference axes are taken as the primary axes, and since the primary axes tend to be positively intercorrelated, most of the variables have positive correlations with the various primaries. Since it may be difficult to identify and interpret the primary axes from these structure values, the primary pattern values are also needed. These pattern values have many vanishing or near-vanishing entries. They also have entries of substantial size. Since these are coördinates rather than correlations they may range beyond 1.00 in value. The entries for the primary pattern would be used to identify the four primary factors.

[1] Thurstone, *op. cit.*, p. 433.

These entries also would be used in writing the equations that describe the variables in terms of the factors, and for reproducing the matrix of intercorrelations of the variables.

The comparability of this solution with Thurstone's is indicated by comparing his simple-structure values with these primary-pattern values. The one set of values is approximately proportional to the other. An exact proportionality would have held, had the two methods identified primaries that coincide exactly.[2] Since no initial configuration was given, it cannot be determined which of the two solutions, if either, gives the more precise reproduction of the configuration. It seems evident, however, that both solutions would lead to the same interpretation. In this sense, then, the new method gives identical results.

One point in selecting the trapezoid problem was to illustrate the application of the new method to a problem in which some of the variables were designed to have what Thurstone calls "negative saturations on some of the basic factors."[2] Variables 14, 15 and 16 were so designed by him for this purpose. The single rotation method, it was seen, reproduced these high 'negative saturations' quite satisfactorily. Thus it would seem that the method is not necessarily restricted to problems that give a completely positive set of simple-structure values. The clue to variables with these high negative loadings appears to be given in the extended-vector representation. There they lie at a considerable distance from the main body of plotted variables. This is true both for the trapezoid problem, and for the box problem, previously referred to. In determining the position of the extended primary axes, it is desirable to take as boundary lines those that run through a number of variables. This follows from the definition of simple and primary axes. If variables with high negative loadings are taken as corners, then generally the lines joining them to the other corners will not pass through points defined by other variables. Such a procedure can thus be rejected on the grounds that the condition of the definition is not being adhered to.

The trapezoid problem also illustrates the economy of the method and the comparability of the solution secured in this fashion with that secured by the conventional methods. These

[1] These basic relationships are discussed in Harris and Knoell, *op. cit.*

[2] Thurstone, *op. cit.*, p. 428.

two illustrations, however, have presented only relatively simple problems in determining the extensions of the primary axes. Not all the sets of centroids that workers commonly wish to rotate present such clear-cut boundary lines in the extended-vector representation. Consequently, the third illustration was chosen to indicate how the procedure may be applied to such problems. In making this application, the requirement that the extension of the primary coincide with the position of an extended variable has been abandoned.

THE 19-VARIABLE PROBLEM

Since the method of making a direct rotation to primary structure is of major concern in this paper, the nature of the 19-variable problem that was analyzed for this third illustration will be described only briefly. The study of student preferences for various literary passages that provided the data for this problem deserves a separate report that will be issued subsequently. Student preferences for twenty different literary passages were secured. Each preference was located on a five-point scale. Intercorrelations (tetrachoric) of these preferences were computed. For one of the passages, more than ninety-five per cent of the sample of one hundred forty fell into the upper section of the dichotomy, and so it was dropped from the study. These intercorrelations were then factored by Thurstone's complete centroid method. Two runs were necessary in order to stabilize the estimated communialities for the four factors that were extracted. The centroids are given in Table 2. The correlation matrix is not given in this paper; it will be presented, along with some discussion of hypotheses that are supported or are contra-indicated by the factor solution, in the separate report.

Extended-vector values were computed and the three diagrams given as Figure 2 were prepared. An attempt was then made to locate boundary lines and their intersections. It can readily be seen from these plots that this problem falls short of an 'ideal' configuration. The study itself was an exploratory one, and the passages had been selected primarily to provide a range of types of literary materials. Such an approach, which is often a necessary one, tends to make the problem of interpretation a difficult one. Empirical observation had suggested that for a four-dimensional problem it should be possible to locate boundary

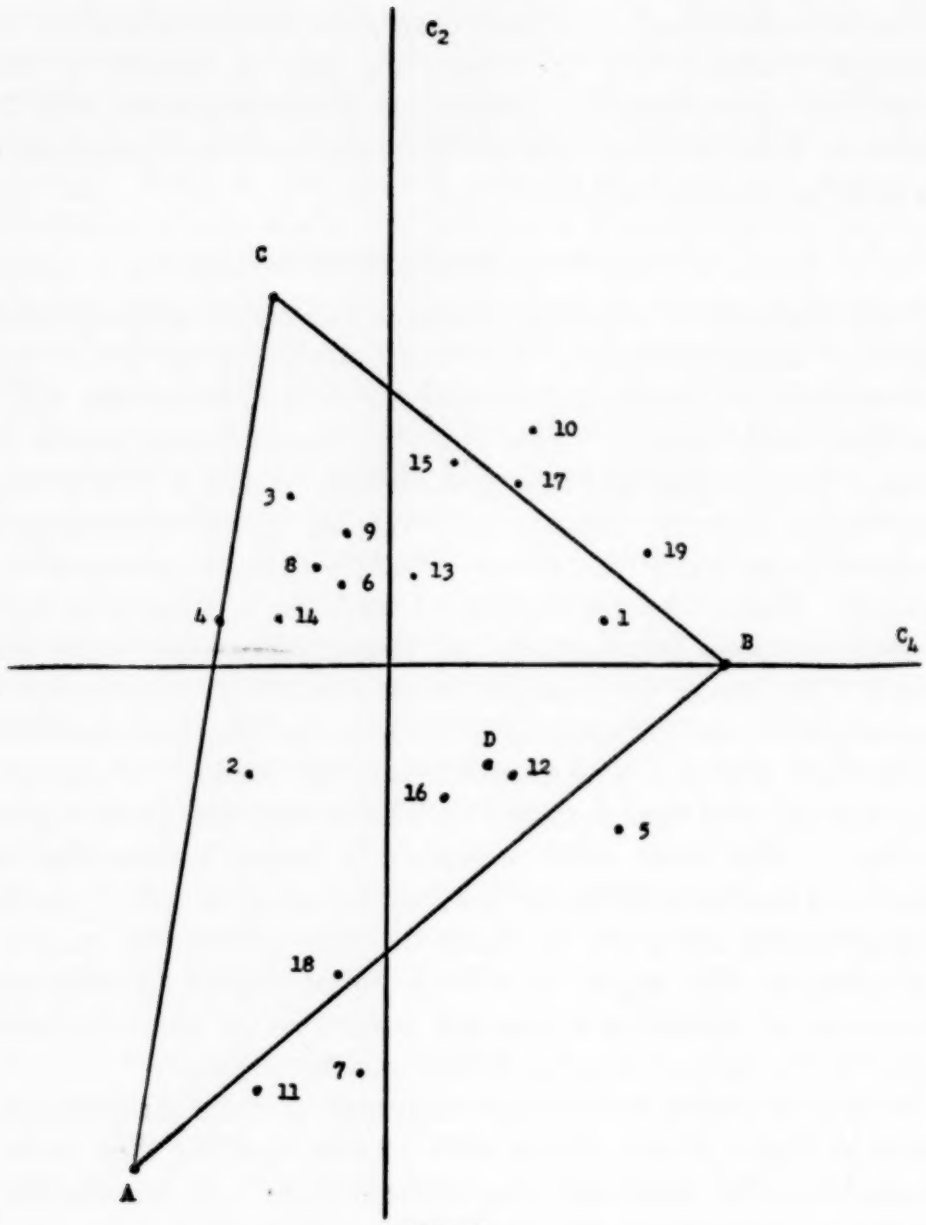

Fig. 2a.

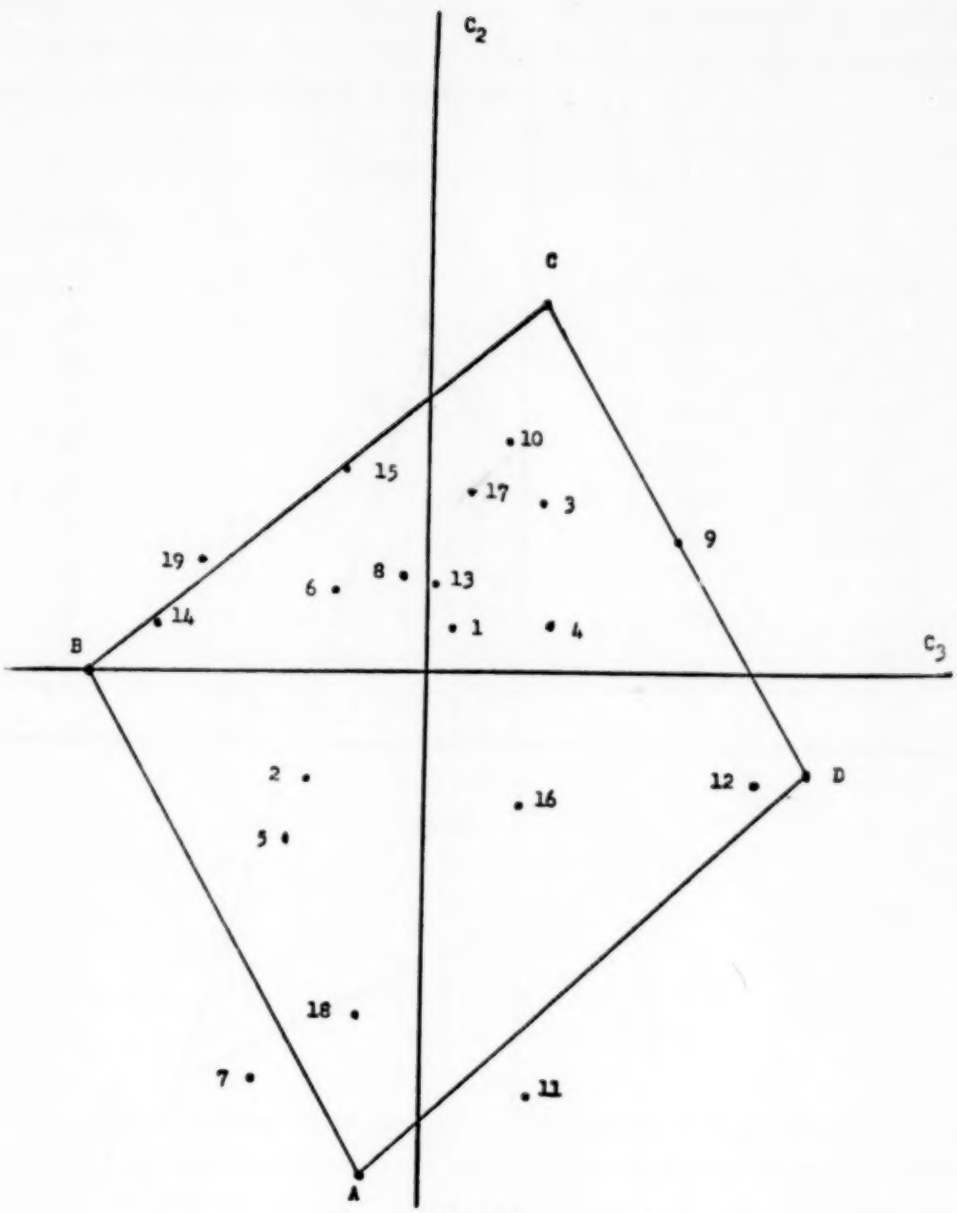

Fig. 2b.

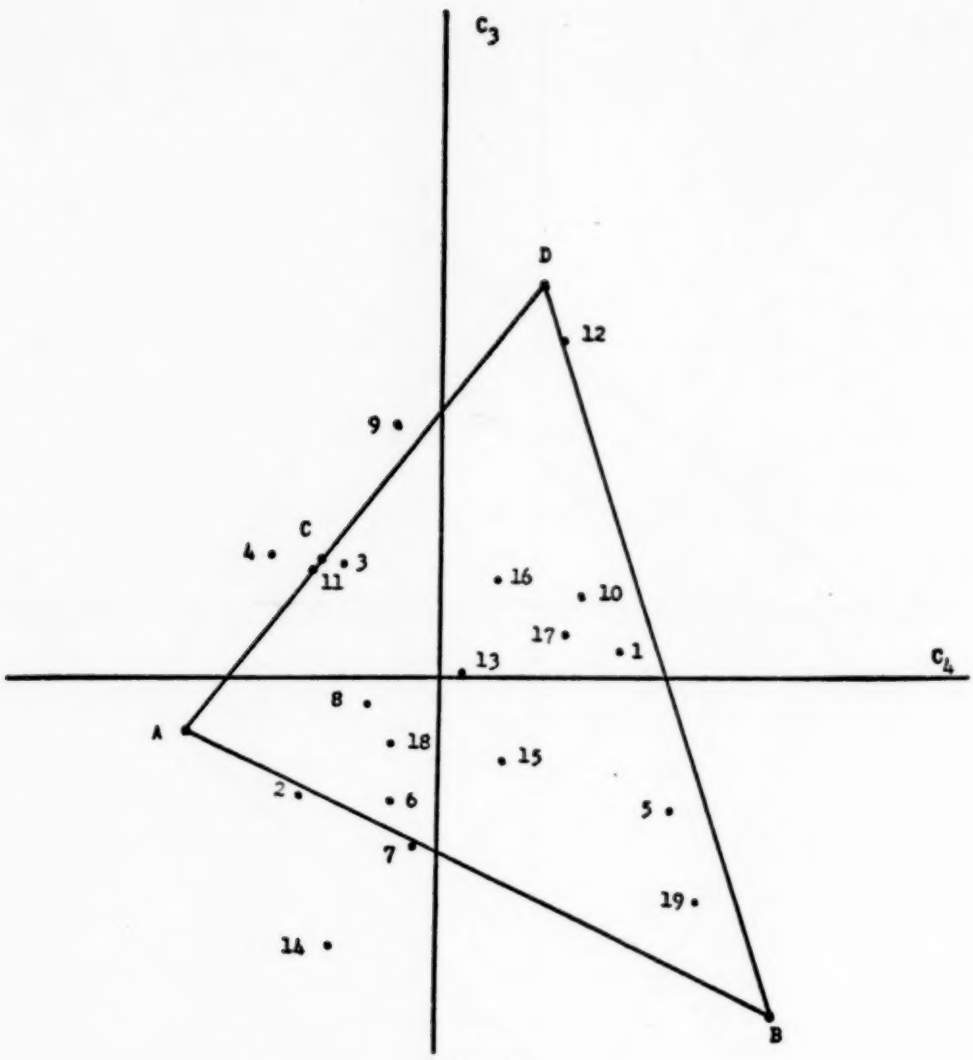

Fig. 2c.

lines that would give one quadrilateral and two triangular figures on the three diagrams. These boundary lines should pass through, or as close to as possible, points marking the extensions of variables. Finally, these boundary lines should enclose practically all the plotted points. With the imposition of these three conditions, the points labeled *A*, *B*, *C*, and *D* were located as the extensions of the primaries.

TABLE 2.—CENTROIDS

Variable	C_1	C_2	C_3	C_4
1	.353	.044	.029	.189
2	.448	−.143	−.159	−.184
3	.559	.279	.189	−.161
4	.671	.095	.249	−.337
5	.558	−.273	−.223	.389
6	.579	.138	−.159	−.084
7	.473	−.569	−.236	−.031
8	.668	.194	−.045	−.141
9	.478	.188	.362	−.063
10	.580	.399	.141	.245
11	.380	−.479	.120	−.144
12	.466	−.154	.463	.174
13	.531	.140	.009	.036
14	.465	.067	−.373	−.147
15	.594	.355	−.146	.113
16	.497	−.201	.144	.084
17	.540	.285	.071	.204
18	.567	−.524	−.110	−.081
19	.489	.160	−.327	.379

These four points were not identified immediately, needless to say. What was done was to make several successive approximations of the boundary lines, and to adjust the intersecting points on the three plots until consistency was achieved. In making the adjustments, the condition of maintaining boundary lines that pass through or close to variables and enclose the plotted points was a guiding one. This illustration highlights the problem of the objectivity of the method. Whether or not another person, following these general conditions, could have

reproduced this solution is not known. Actual tests are needed, and will be made. When considered with reference to a standard of complete objectivity, there seems to be little doubt that the method must be judged somewhat unsatisfactory for many problems. The two previous illustrations, however, indicate that a high degree of objectivity may be secured when the problems are fairly 'neat.' When considered with reference to the degree of objectivity given by present rotation methods, the objectivity of the method of direct rotation to primary structure may compare favorably.

The direction numbers of points A, B, C, and D were taken as extended-vector values, and read directly from the plots. These numbers and the direction cosines are:

	P_A	P_B	P_C	P_D
I	1.00	1.00	1.00	1.00
II	−1.50	.00	1.10	−.30
III	−.15	−1.00	.35	1.15
IV	−.75	1.00	−.35	.30

	P_A	P_B	P_C	P_D
I	.511	.577	.638	.632
II	−.766	.000	.702	−.190
III	−.077	−.577	.223	.727
IV	−.383	.577	−.223	.190

The primary solution is given in Table 3. The first four columns give the structure, and the last four the pattern. The intercorrelations of the factors are:

	P_A	P_B	P_C	P_D
P_A	1.00			
P_B	.12	1.00		
P_C	−.14	.11	1.00	
P_D	.34	.06	.39	1.00

These data were taken as the basis for the interpretation of the study.

This solution is a satisfactory one, in that a number of the pattern values are relatively small and a number of the variables have a complexity of one. Thus, it should be possible to identify, at least tentatively, these factors. No attempt to discuss these

TABLE 3.—PRIMARY SOLUTION

Variable	Structure				Pattern			
	r_{jP_A}	r_{jP_B}	r_{jP_C}	r_{jP_D}	P_A	P_B	P	P_D
1	.072	.296	.220	.272	−.02	.27	.10	.23
2	.421	.244	.191	.160	.49	.16	.29	−.13
3	.119	.121	.631	.407	.16	.03	.61	.11
4	.380	.049	.625	.523	.44	−.08	.64	.13
5	.362	.675	.028	.316	.18	.65	−.12	.26
6	.235	.377	.450	.208	.31	.29	.50	−.11
7	.708	.391	−.143	.230	.64	.32	−.10	.03
8	.250	.330	.584	.326	.32	.22	.62	−.04
9	.097	.031	.532	.518	.04	−.04	.41	.35
10	−.114	.395	.627	.440	−.20	.35	.44	.32
11	.607	.067	−.035	.391	.52	.00	−.05	.24
12	.254	.102	.254	.693	.01	.06	−.02	.70
13	.150	.322	.431	.322	.13	.26	.38	.11
14	.271	.399	.293	−.018	.42	.32	.46	−.36
15	.000	.492	.570	.223	.03	.43	.54	−.02
16	.365	.252	.189	.473	.23	.20	.06	.36
17	−.026	.388	.515	.378	−.10	.34	.36	.25
18	.731	.344	−.013	.363	.66	.26	.00	.12
19	.007	.690	.267	.113	−.06	.68	.18	.02

findings in detail will be made here. The general conclusions are that the form of the passage (verse, narrative, drama, etc.) cuts across the factors, and that the factors are identifiable primarily in terms of the subject-matter of the passages. That it should be possible to analyze student preferences for literary passages primarily in terms of the subject-matter of the passages would seem to be a reasonable finding. As such, it indicates that the method of direct rotation to primary structure can give a 'meaningful' solution.

CONCLUSION

An attempt has been made to illustrate the potentialities of a method of rotation that takes, as its point of departure from

present methods, the location of the primary rather than the simple axes. The procedures that have been found effective so far for locating the primary axes have been described. If these procedures are effective for a given problem, then the method has as its outstanding advantage the economy of requiring only a single rotation. Certain aspects of the generality of the method have been pointed out, and the problem of the objectivity of the method in dealing with certain sets of variables has been stressed. It is hoped that other students may find occasion to make use of this method, and thus provide further tests of its applicability.

THE EFFECTS OF INDIVIDUAL VARIABILITY ON ACHIEVEMENT*

OSCAR P. RAUSCH

New Mexico State Teachers College

The last several decades have seen a great increase of interest in individual differences. In educational circles, the literature on individual differences has been voluminous. Many research studies have been published regarding the causes, extent, and effects of such differences among pupils and students. Results obtained from these studies have formed the basis for the reorganization of curricula and revision of methods of teaching in many of the school subjects. These studies have dealt primarily with differences among individuals. Very large differences, however, are also found within the individual himself which may be of equal significance to the educator.

The amount of literature on individual variability, or differences within the individual, has been rather limited. The investigations that have been made have been concerned almost exclusively with the extent of individual variability. A very few have studied the relationship between individual variability and intelligence and the relation of individual variability to emotionality. The scarcity of literature on individual variability has been pointed out by a recent investigator.[1] The effects of individual variability on actual school or college achievement has been almost entirely neglected by investigators. The present study proposed to attempt to study such effects.

The investigation dealt with the effects of individual variability on achievement of college freshmen. It included the effects of such variability in a psychological examination, on an English test, and on personal traits. The study limited itself to the effects on scholastic achievement. It is concerned with academic abilities only to the extent that they aid in better interpretation of the effects on achievement. In no way did the study attempt to discover causes of individual variability.

Data for the study were collected on 1551 college freshmen

* Extract from dissertation by the author for the Ed.D. degree at Indiana University.

[1] Gray, Susan W., "The Relation of Individual Variability to Intelligence," *J. Ed. Psy.*, April, 1944, pp. 201–210.

enrolled in Indiana University between the inclusive dates of May, 1942, and January, 1943. Of the 1551 students, 891 were men and 660 were women. Data were collected only on students who had:

1) Enrolled in at least ten semester hours of work.
2) Taken both entrance examinations.
3) Completed the study for the semester and received grades for that semester.

A few students who were considerably older than the group, in general, were not considered.

Of the above students, 1097 finished the second semester of study. These consisted of 547 men and 550 women. Identical procedures were followed for the two semesters for the purpose of obtaining comparative data. It should be noted that many of the student withdrawals from college before completing two semesters were due to war-time conditions.

University records furnished the source for the data. Two standardized tests were given to entering freshmen. The tests used were the American Council on Education Psychological Examination, 1941 Edition,[2] and the Coöperative English Test, Form PM.[3] The Psychological Examination has three parts: Quantitative, Linguistic, and Total. The Coöperative English Test is composed of four parts; namely, English Usage, Spelling, Vocabulary, and Total. Data on personal traits of the students was obtained from rating sheets supplied by their high-school principals. Each principal was requested to rate students who were entering Indiana University on various personal traits. The five traits on which the individual variability was considered were, as follows: self-management, industry, initiative, leadership, and social adjustment.

Since raw scores on educational and psychological tests ordinarily have little significance and cannot be directly compared from test to test, it was necessary to convert these scores into equivalent units to reduce them to a common basis. The use of the percentile rank for this purpose was not considered, as

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[2] Thurstone, L. L. and Thurstone, Thelma G., *American Council on Education Psychological Examination*, The American Council on Education, Washington, D. C., 1941.

[3] Leonard, Sterling A., *et al.*, *Cooperative English Test, Form PM*, Coöperative Test Service, New York City, 1939.

it has some distinct limitations. The primary objection to the use of percentile ranks is the fact that interpercentile distances fluctuate in magnitude throughout the scale. To avoid the practical disadvantages of the z-score, the T-score was used. This eliminated the necessity of dealing with negative scores and with scores expressed as decimal values. Personal traits were rated by the principals on the basis of 1 to 100, and were, therefore, in comparable units.

As a criterion for academic college success, the average credit point average was used. At Indiana University each hour of credit receives the following points for the various marks: A = 3, B = 2, C = 1, D = 0, and F = −1. The average credit was determined by dividing the number of credit by the number of hours enrolled.

After the above calculations were completed, the statistical procedures employed may be summarized as follows:

1) Division of all the freshmen into three groups; namely, the least variable group, the middle group, and the most variable group.

2) Calculation of the mean, standard deviation, and standard error of the mean for each group.

3) Calculation of the standard error of the difference between means.

4) Determining the ratio of the actual differences to the standard errors of differences in order to test the significance of the difference.

THE EFFECTS OF INDIVIDUAL VARIABILITY ON THE PSYCHOLOGICAL EXAMINATION

The 1551 students were divided into three groups based on their individual variability between the Q and L scores. The extent of the differences were less than four scores for the least variable group, from four to eight scores for the middle group, and more than eight scores for the most variable group. The least variable group exceeded the other two groups in scholastic achievement by a wide margin, and its achievement record was also superior to that of the total freshmen group. Table I presents the comparative achievement of the various groups. It will be noted that there was no difference in academic achievement between the middle group and the most variable group.

TABLE I.—COMPARATIVE ACHIEVEMENT OF GROUPS ACCORDING TO INDIVIDUAL VARIABILITY ON PSYCHOLOGICAL EXAMINATION

Group	Number	Mean*	SD
Least Variable	471	1.17	.83
Middle	539	1.04	.86
Most Variable	541	1.04	.84
	1551	1.08	.85

* Average credit point.

In order to determine whether the difference between the achievement of the groups was actually significant, it was necessary to find the ratio of the differences between the means and the standard errors of the differences. In the past, statisticians and research workers have frequently demanded that the obtained difference between two means be three times as large as the standard error of the difference before regarding it as significant.[4] More recent practice is to regard a critical ratio of 2.50 sufficiently high to indicate significance.[5] The data portrayed in Table II would seem to justify the conclusion that individual variability on the Psychological Examination adversely affects college achievement.

TABLE II.—PAIRED COMPARISONS OF DIFFERENCES ON SCHOLASTIC ACHIEVEMENT OF GROUPS ARRANGED ACCORDING TO INDIVIDUAL VARIABILITY ON PSYCHOLOGICAL EXAMINATION

Groups	Mean Differences			Chances in 100 of a True Difference
Least Variable Middle	.13	.053	2.45	99.3
Least Variable Most Variable	.13	.052	2.50	99.4
Middle Middle	.00	.00	.00	50.0

Since the quotients of the differences divided by the standard error of difference are 2.45 and 2.50, respectively, there are over

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[4] Garrett, Henry E., *Statistics in Psychology and Education*, Longsman, Green & Co., New York, 1940, p. 213.

[5] Lindquist, E. F., *A First Course in Statistics*, Houghton-Mifflin Co., Boston, 1942, p. 132.

ninety-nine chances in one hundred that the achievement of the least variable group will be superior to that of either of the other two groups.

As further evidence regarding the superiority in achievement of the least variable group, the fact may be cited that twenty-nine per cent of this group were in the highest achievement quartile, while only twenty per cent were found in the lowest quartile.

It was considered advisable to check on the results in one other way. It may be questioned whether the superiority of the least variable group was actually due to less individual variability or to higher scores in one or the other parts of the test. In other words, did a large proportion of the students in this group have their highest score in either the quantitative or linguistic part of the Psychological Examination, and did this explain the superior achievement? By actual count it was discovered that two hundred twelve of the least variable group had a higher Q score, while of two hundred two students the opposite was true. The other fifty-seven students had identical scores on both parts of the test. It may be of interest to know that of the most variable group, two hundred seventy-eight had the highest score in the quantitative part of the test, whereas two hundred sixty-three showed superiority in the linguistic section. This seems to indicate that the differences in academic achievement could not have been due to this factor.

A separate investigation was made of the men and of the women students. The results on the academic achievement of the men students showed considerable similarity to those of the total group. In general, the women students had higher achievement scores than the men. While the least variable group of the women again exceeded the scores of the other two groups in scholastic achievement, the most variable group did receive higher achievement scores than the middle group. This could possibly be due to the fact that the large variation on the scores of the Psychological Examination by the most variable group was due, in many instances, to very high scores in the linguistic part of the test. The fact remains, however, that the least variable group of the women exceeded both other groups in achievement. This can be further ascertained by the fact that thirty per cent of the least variable group were in the upper quartile in scholastic achievement.

Of the 1551 students who finished one semester of work, only 1097 completed the courses for a second semester. It could be possible for individual variability to have different effects on scholastic achievements during the second semester when adjustment problems are less difficult. This part of the study was limited to the grades received at the conclusion of the second semester. The percentage of withdrawals varied less than five per cent among the three groups, so that this factor did not eliminate comparable study. The highest gain over first semester achievement was made by the middle group, although the achievement of the least variable group remained the highest of the three groups. The results seemed to indicate that individual variability continued to affect general achievement as students progressed through college. A statistically significant difference was found in second semester achievement between the least and the most variable groups. It is worthy of note that over thirty-six per cent of the men students in the most variable group were in the lowest quartile in scholastic achievement, while the difference between the achievement of the women between the least variable and the most variable groups increased considerably in favor of the former group.

The data in the study seemed to indicate that an inverse relationship exists between individual variability as it pertained to the Psychological Examination and between individual variability and achievement in college. A study of second semester achievement strengthened the evidence that such variability adversely affects college success.

THE EFFECTS OF INDIVIDUAL VARIABILITY ON THE ENGLISH TEST

The same procedures as the ones described previously were used to study the effects of variability on the English test. The results did not reveal significant differences, but they did indicate a tendency for the least variable group to surpass the achievement of the other groups. To aid in the interpretation of the findings, an investigation was made of the scholastic aptitude of the various groups as measured by the American Council on Education Psychological Examination. This investigation yielded surprising results. In fact, the means on the Psychological Examination of the three groups were inversely related to their achievement. This appears to be conclusive evidence that the

inferior scholastic record of the most variable group cannot be attributed to lack of academic aptitude. This fact is illustrated in Table III.

TABLE III.—MEANS OF GROUPS IN ACHIEVEMENT AND ON PSYCHOLOGICAL EXAMINATION

Group	Credit Point Average	Mean on Psychological Examination
Least Variable	1.12	49.82
Middle	1.07	50.45
Most Variable	1.06	52.14

In determining the reliability of the differences on the Psychological Examination, it was found that the differences between the obtained mean on the Psychological Examination of the most variable group and the means of the other two groups on the same test were significant in favor of the former group.

Equally striking results were obtained when comparative data of the percentage in the highest and lowest quartiles on achievement and on the Psychological Examination were studied. These data are given in Table IV.

TABLE IV.—PROPORTIONATE PER CENT IN HIGHEST AND LOWEST QUARTILES IN ACHIEVEMENT AND ON PSYCHOLOGICAL EXAMINATION

Group	Highest Quartile		Lowest Quartile	
	Achievement	Examination	Achievement	Examination
Least Variable	26.0	23.0	22.8	28.5
Middle	25.5	22.8	26.2	26.8
Most Variable	23.3	29.8	26.3	20.8

The data given in the Tables III and IV seem to exhibit rather conclusively that individual variability does have detrimental effects on achievement. They demonstrate the wisdom of

considering the consistency of part scores on a test. Although two students may have the same composite score, their chances for success in college are not necessarily the same. In fact, the evidence presented by these data cast a shadow of doubt on the validity of the so-called 'average' score as an instrument for guidance.

It was deemed advisable to ascertain whether the individual variability was due to a preponderancy of either high or low scores in any one part of the English Test. If this were true, it could possibly be a factor affecting achievement. Investigation of the original data revealed that the largest percentage of students in each of the three groups had their highest score in the Vocabulary section of the test, and the lowest score for the greatest number in each group was Spelling. All the data seemed to point to the conclusion that individual variability on the English Test was not conducive to satisfactory scholastic success. Academic aptitude, as measured by the Psychological Examination, did not compensate for the detrimental effects of such variability. In fact, individual variability may be a major factor in precluding higher coefficients of correlation between aptitude tests and scholastic achievement.

A study of second semester results showed that the greatest increment in achievement from the first to the second semester was made by the least variable group. In general, no evidence was found that the second semester results differed to any extent from those found in the first semester.

THE EFFECTS OF INDIVIDUAL VARIABILITY IN PERSONAL TRAITS ON GENERAL ACHIEVEMENT

A rating on personal traits of the entering freshmen college students was obtained from their respective high-school principals. The five traits considered were: self-management, initiative, industry, leadership, and social adjustment. Although these were subjective ratings, it could be safely assumed that the principals who had personal contacts with these students over longer periods of time should be qualified to judge personal traits in a fairly satisfactory manner. Perhaps, such ratings are even more accurate than those obtained from personality tests which have not reached the stage of validity possessed by mental and achievement tests.

The ratings ranged from one point for the lowest to a maximum high mark of 100. All rating units were of equal value to make direct comparisons possible. The students were again divided into three groups according to the magnitude of individual variability among the personal traits. The extent of the differences ranged from a maximum of ten for the least variable group to a minimum of twenty for the most variable group. On some of the students no ratings of personal traits were obtained, so the number of students is somewhat smaller than it was in the preceding investigations.

The achievement of the least variable group surpassed that of the others to such an extent that it became obvious that they must have some significance. This is apparent from a study of Table V.

TABLE V.—COMPARISONS OF ACHIEVEMENT OF THREE GROUPS ARRANGED ACCORDING TO INDIVIDUAL VARIABILITY IN PERSONAL TRAITS

Group	Number	Mean	SD
Least Variable	460	1.35	.83
Middle	503	1.06	.80
Most Variable	398	.85	.84
Total	1361	1.10	.84

It was found that the obtained differences between the means were significant in every instance in favor of the less variable group.

Equally as striking as the foregoing data was the result of a study determining the percentage of each group in the highest and lowest quartiles of achievement. The least variable group had thirty-six per cent of its members in the highest quartile and only sixteen per cent in the lowest quartile at the other extreme; the most variable group characterized by its unevenness in personal traits had less than fifteen per cent in the highest quartile and over thirty-four per cent in the lowest quartile.

It should be stated that the extent of variability was not due to a preponderancy of either high or low ratings in any specific trait.

The study seemed to furnish sufficient evidence that students

showing an evenness in personal traits far excel in achievement over students who show high ratings in some and rather low ratings in other traits.

CONCLUSION

The results of the foregoing investigation almost invariably indicated that heterogeneity of the individual in the various abilities and traits is not conducive to superior achievement.

The average score on separate tests or on the various parts of the same test does not have any accurate predictive value concerning future achievement. For instance, a score of 50 on each of two separate tests does not have the same significance as respective scores of 70 and 30 on the same tests, although the average score would be identical. As a result, an average score on separate tests or on different parts of the same general test does not form a reliable basis for individual guidance. Teachers and counselors must be concerned with all of the separate measures of the individual that may have been obtained.

PERSONALITY TESTS IN A UNIVERSITY GUIDANCE PROGRAM

LILLIAN G. PORTENIER

University of Wyoming

For purposes of guidance the counselor of university students is concerned not only to determine the capacity of his advisees for university work, but also to discover their interests in and attitudes toward the courses prescribed. No single test nor battery of tests thus far available measures all the factors essential for success in the various college curricula. The most serious weakness is found in tests for evaluating personality characteristics, interests, and attitudes, all of which are highly important for effective work. Probably the single most important reason why our predictions of educational success are no more accurate than they now are is that we base them far too much on measurements of ability alone and neglect the influence of personality traits.

The perfection of techniques for the appraisal of personality has lagged far behind that for the measurement of ability. Although numerous questionnaires and inventories are now available, very few studies show any consistent relationship between the test results and academic success. Vagueness of terminology is, perhaps, a major shortcoming of the present psychometric instruments in this field. Moreover, the terms used by the authors possess no universally accepted meanings. Not infrequently a given term is used in widely different senses by different writers and even by the same writer at different times. The admitted shortcomings of the tests now in use, however, should not blind us to the importance of making as accurate appraisal of students as possible with the better tools now available.

In discussing the field of personality, interest, attitude and character tests, E. B. Greene[5] uses the phrase, 'modes of adjustment,' a phrase admittedly very broad in scope but highly pertinent because truly indicative of the numerous "ways in which a person approaches a goal." For valid personality tests should appraise the total circumstances of life that have affected the persons tested. This fact, of course, enhances rather than detracts from the meaning and usefulness of such psychometric

tools. The highly constructive purposes for which any tests can be used are determined to a significant degree by the extent and accuracy with which the subject's performance reflects in some measure all the actual conditions of his life.

Few if any of the questionnaires and inventories now in use have been perfected to a point where the final score yields any high degree of certainty of prediction with respect to an individual case. Despite these limitations, however, some instruments designed to diagnose personality problems are used extensively and appear to have real psychological value to the counselor of students.

The present study was undertaken in order to evaluate some of the personality tests widely used as practical tools in counseling programs for university students. Data were compiled for scores on the Bell Adjustment Inventory, the Bernreuter Personality Inventory, the Minnesota Multiphasic Inventory and the Allport Vernon Study of Values. These tests had been administered to students enrolled at the University of Wyoming during the school year 1947–1948, at varying times after their first enrollment. Most of these students were veterans who had taken the tests as part of the routine while going through advisement, or were students who had been referred to the personnel department for academic or personality problems. Consequently, the group for which data were compiled was not a representative sampling of all students enrolled. With very few exceptions the veterans were men, and since the ratio of men to women on the campus during this period was about three to one, most of the data for civilians were also for men. Of the one hundred twenty-one students for whom results were available from the Bell Adjustment Inventory, only two were women. The number of women taking each of the tests was very small; therefore, their scores were not included in analyzing the test results. In short, all Wyoming data used in the study are for men.

The Bell Adjustment Inventory[2] consists of one hundred sixty items, chosen on their ability to discriminate between well-adjusted and poorly-adjusted students as selected by faculty members, on their correlation with items in similar inventories, and on clinical experience. The group of students for which

data were compiled ranged from a score of zero on one or more of the subtests and five on the total test—indicating excellent adjustment, to scores of twenty and above on the subtests and from sixty to eighty for the total score which, according to the norms, are indicative of very unsatisfactory adjustment. More than three-fourths of the students taking the test earned scores which gave them ratings above average, i.e., good or excellent, on at least one of the subtests, and only one-fourth were rated unsatisfactory or very unsatisfactory on the basis of the total score earned. The poorest ratings were found for home and social adjustment and the best for health adjustment. The categories of adjustment—home, health, social, and emotional—are entirely empirical. One may well question to what extent they are distinct and meaningful types of adjustment and whether the questions can with accuracy be answered simply 'Yes' or 'No,' as required. The generally favorable rating for all students on the subtests and on the total test was one of the most pronounced characteristics revealed by an analysis of the test scores.

One of the most widely used and best known instruments in the field of personality measurement is the Bernreuter Personality Inventory.[3] It is made up of one hundred twenty-five questions to which the subject must answer 'Yes,' 'No,' or 'Doubtful.' Measurement of six important traits of personality with one instrument is the unique feature claimed for the Bernreuter Inventory. To the original four scales derived by Bernreuter, viz. neuroticism, self-sufficiency, introversion-extroversion, and dominance-submission, have been added self-confidence and sociability. Studies by means of factor analysis seem to indicate that the latter two traits are the chief components of the original four and consequently are the only ones actually measured.

Scores for each of the six traits on the inventory were compiled for one hundred twenty-seven students. A large majority of the scores were negative or very low positive, which is indicative of desirable traits. Very few students scored high on the scales for neurotic tendency, introversion-extroversion, self-confidence and sociability. Persons scoring low on these scales tend to be emotionally stable, extroverted and free from worry, whole-

somely self-confident, sociable and gregarious. About one-fourth of the group scored high on the scale for self-sufficiency and two-thirds on dominance-submission. Persons who score high on these scales prefer to be alone, rarely ask for sympathy or encouragement, ignore the advice of others, and tend to dominate others in face-to-face situations. These scales also revealed a tendency for students to place themselves in a socially acceptable light. It has been shown that college students tend to rate themselves too high on favorable traits when filling out personality questionnaires, and that it is possible to influence the scores on the Bernreuter test significantly by deliberately answering questions in conformance with conventional standards.

Although carefully developed by statistical methods the Bernreuter test failed to demonstrate its validity in actual practice. Landis and Zubin found that it cannot discriminate between college students and hospitalized psychotics, and a summary of almost two hundred studies in which the inventory was employed disclosed contradictory claims made for it and also failed to demonstrate its validity. High scores appear to be indicative of poor adjustment, but low scores may not be associated with wholesome, well-balanced personalities. Asking a student what he does, or how he feels, are direct questions and intelligent subjects can readily determine acceptable responses. Since the validity of the test is dependent largely on the truthfulness of the subject's responses, the value of such an instrument for educational and vocational guidance is greatly curtailed. Students scoring high on some scales may have revealed their maladjustment by making honest responses; on the other hand, however, some clever students may think it to their advantage to feign maladjustment. While such tools may appear to be simple short-cuts for solving human problems, they are not a substitute for sound psychological insight in counseling students.

The problem of validation of personality tests has proved particularly difficult. Nevertheless, some progress has been made in the validation of the questionnaire type of test by Hathaway and McKinley.[6] In developing the Minnesota Multiphasic Personality Inventory, only those items were selected, from a very large number, which actually differentiated subjects with known psychiatric diagnoses from people in general. Up to the

present time the chief usefulness of the instrument has been as an aid in making psychiatric diagnoses on abnormal or severely maladjusted cases. It was derived and validated in a psychiatric clinic, but no doubt can be used successfully in differentiating between different kinds of normal people.

The Multiphasic Inventory is designed to provide scores on all the more important phases of personality in a single test of five hundred fifty statements covering a wide range of subject-matter. Each statement is printed in simple language on a single card. The subject is required to sort all the cards into three categories, 'True,' 'False,' and 'Cannot Say.' A simplified record sheet on which the number of cards thus sorted are tabulated, provides a record to be scored by any one of the various keys.

Scores were available for fifty-one students on the Minnesota Multiphasic Inventory. The inventory provides three checks on the validity of the scores in the profile. According to the Manual, "the number of invalid records is dependent upon the group being studied, but among routine cases it will rarely run higher than five per cent." A significant point noted in analyzing the fifty-one profiles was the large number—about twenty-five per cent—of invalid scores. While these scores may not invalidate the records, they do indicate a need for cautious interpretations, and again indicate that the subjects may be attempting to falsify their scores. Almost one-half of the F scores were about 70, which is a sign of invalidity. It may mean "the subjects were careless or unable to comprehend the items, or that someone made extensive errors in entering the items on the record sheets."

A very limited number of abnormally high scores were found in the profiles for the group of fifty-one students. The highest number, about fifteen per cent, was found on the Interest scale for masculinity-femininity. Since all of the subjects were men, the high scores indicate a deviation of the basic interest pattern in the direction of femininity. High scores on this scale must not be interpreted to indicate homosexual abnormality in the absence of other and corroborating evidence, although the personnel consultant should keep in mind the masculinity level of the student in offering vocational advice. As a group university

men tend to score slightly more in the direction of femininity than toward masculinity.

Fourteen per cent of the men also scored abnormally high on the scale for Psychopathic Deviate, which indicates absence of deep emotional response, inability to profit from experience, and disregard of social mores. No data were found which indicate a difference between veterans and civilians on this scale but it is interesting to note that most of these students were veterans.

Again the profiles for most students were generally favorable, but not to the extent found on the Bell and Bernreuter inventories. Selection may be a factor accounting for the poorer scores on the Minnesota Inventory. Most of the students who took the test had earned unfavorable scores on the Bell and/or on the Bernreuter inventories.

Eighty men had taken the Allport-Vernon Study of Values test.[1] This test is designed to measure the relative prominence of six basic interests or motives based on Spranger's types: Aesthetic, Economic, Political, Religious, Social, and Theoretical. These interests or values are said to be enduring, deep seated orienting trends rather than transient interests determined by the immediate situation.

The average scores for the Wyoming group agreed with the norms listed for the Social value only. The authors have found the test of Social value less discriminating and less reliable than that for the other five values or interests, due largely to the vagueness of the term. The average scores for the Religious and Theoretical values were higher than the general norms, and somewhat lower for Aesthetic, Economic and Political values. The Wyoming average for Theoretical value was closely similar to the averages listed for a group of students in engineering and for a group of commercial students; the Religious score approximated that for Boy Scout leaders; while the average score for Economic value was identical with that listed for a group of law students, and the Political with that for students in engineering.

The relationship which has been found between the test profile and academic and vocational interests in some studies should make the Study of Values a valuable tool for the guidance counselor. Its weakness, however, is similar to that of personality inventories. The direct questions make it possible for the intelli-

gent student to secure a desired profile. Another major criticism of the test is the difficulty in precise definition of terminology due to the marked overlapping among the fields of interest. Nevertheless, a degree of validity has been demonstrated for the test by fairly high correlations between the test scores and differential scores on the Strong Vocational Interest Blank. Its validity has also been confirmed by significantly different scores for students in different colleges and for different occupational groups.

Personality tests, nevertheless, are not infallible. Thirty-four of the students had taken two, three, or all four of the tests. In some instances there was fairly close agreement between the scores for similar traits on different tests, as, e.g., Social Adjustment on the Bell Inventory and Sociability on the Bernreuter. For a few students the entire profile on a second test tended to confirm the general interpretation from an earlier test, but there were many pronounced discrepancies. Frequently, widely differing interpretations might have been made on the basis of results on two different tests for the same subject. This finding further emphasizes the importance of interpreting test scores or profiles in the light of other information. A test is merely an aid in diagnosis.

The four personality tests analyzed above are all of the questionnaire type and should be evaluated in light of the limitations of such tests. Studies indicate that the reliabilities of most questionnaires are generally high enough to rely upon the results in determining group differences but not sufficiently high to justify reliance on test scores for individual diagnosis.

The low validity of many questionnaires is, perhaps, their greatest weakness. Some studies found the Bernreuter Inventory unsuccessful in differentiating seemingly normal college students from those who later developed personality difficulties. However, failure to predict college problems is not necessarily a valid criticism of a test, since many relatively serious maladjustments of college students are not discovered.

Some studies seem to indicate that personality tests of the questionnaire type can be used most successfully in an environment characterized by conflict and frustration, as in the army. This may account, in part, for their low validity in predicting

personality problems in students on a relatively peaceful university campus.

The practice of using ratings by teachers and friends as a criterion in validating questionnaires is highly questionable. The judgments of intimate acquaintances are seldom wholly impersonal.

As mentioned earlier, questionnaires are unsuccessful without a reasonable degree of coöperation, since an able student will have little difficulty in concealing personality patterns which he hesitates to acknowledge. Censorship is readily exercised. Conscious or unconscious repression may result in a student giving honest answers which are incorrect. Questionnaires measure what the person looks like to himself; repression may prevent him from recognizing some of his undesirable characteristics.

It would seem, then, that personality tests are practical and useful instruments for a guidance program only if their limitations and weaknesses are thoroughly understood and allowance made for them. The interpretation of test scores should always be made in the light of other data and supplemented by sound psychological insight. A personality test is but one of many tools which may assist the counselor to understand the student and to guide him in finding an acceptable solution for his problems. The proper interpretation of the most valid tests of personality requires skill and judgment, and wise application of results must await sound interpretation.

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ON METHODS OF MEMORIZING POEMS AND VOCABULARIES

E. L. THORNDIKE

Teachers College, Columbia University

In my files of experiments completed but not reported I find data which seem worth a short note.

ON LEARNING BY THE 'WHOLE' METHOD VERSUS LEARNING BY THE 'PART' METHOD

College students studied one of the poems shown below by reading it again and again from its first word to its last, and the other poem by such piecemeal repetitions as they chose to make.

A

So bring him: we have idle dreams:
  This look of quiet flatters thus
  Our home-bred fancies: O to us,
The fools of habit, sweeter seems
To rest beneath the clover sod,
  That takes the sunshine and the rains,
  Or where the kneeling hamlet drains
The chalice of the grapes of God;
Than if with thee the roaring wells
  Should gulf him fathom-deep in brine
  And hands so often clasp'd in mine,
Should toss with tangle and with shells.

B

Lo, as a dove when up she springs
  To bear thro' Heaven a tale of woe,
  Some dolorous message knit below,
The wild pulsation of her wings;
Like her I go; I cannot stay;
  I leave this mortal ark behind,
  A weight of nerves without a mind,
And leave the cliffs, and haste away
O'er ocean-mirrors rounded large,
  And reach the glow of southern skies,
  And see the sails at distance rise,
And linger weeping on the marge.

Except for information describing the two methods and providing that approximately half of the persons should use the 'whole' method first, the students managed their own learning, the experiment being intended to interest them in methods of memorizing rather than to advance knowledge. Dishonest reports were, I am sure, rare and would be as likely to favor 'whole' as 'part' methods.

The results clearly support the superiority of piecemeal memorizing as a practical procedure in committing to memory speeches, long quotations and the like. Eleven persons spending in each case equal times by the two methods remembered on the average sixty-six words by the 'whole' method and seventy by the 'part' method. Eleven persons learning to complete mastery by each method required four per cent less time by the 'part' method. Twenty persons who learned to approximate mastery spent six per cent less time by the 'part' method and remembered ten per cent more words (76.5 versus 68.5). I have also records from one hundred thirty persons who failed to report the times spent. Their median scores were sixty-nine and seventy-five words by the 'whole' and 'part' methods, respectively. There is no reason to suppose that they spent more time in the latter case.

In this connection I suggest that teachers of psychology remind students that the most important use of memory of a long piece of connected discourse; namely, in speeches, does not require memory to connect the parts. Notes on a card or on one's cuff will suffice for that.

ON LEARNING BY REPETITION VERSUS LEARNING BY REPETITION AND RECALL

College students studied one of the two vocabularies below by simply looking at each nonsense word and its English equivalent again and again and the other by doing so a few times and then covering the English equivalents, trying to recall them, and looking at them only to check the successes of their recalls or when in doubt. The latter method gave better results, though its superiority was less than that found by Gates for the learning of series by school children. The six persons who made perfect scores by both methods took a third less time by the second. Forty-two persons who spent on the average 11.4 minutes by the first and 11.3 minutes by the second remembered twenty per cent

more words by the second. The words were, of course, presented in a scrambled order in the tests.

A		B	
gapesh	ignorant	hilysp	interest
buvorl	danger	feborm	central
lotick	efficiency	buxats	general
hekumb	refined	jimers	prevailing
gisart	weight	ramilp	life
cajang	bodily	towest	should
texosk	capable	govant	those
dirurs	more	necyrp	order
bopisp	prepare	gunemp	relation
fugers	them	madisk	into
lazyll	children	keford	subject
jubent	twenty	dipack	together
milurg	day	mupess	between
decord	knowledge	logush	longitude
tofang	may	setont	other
rumids	energy	karils	known
fodich	besides	dolust	native
sinoft	take	lajink	possible
kaceld	their	casech	because
gedark	condition	pekarn	student

USE OF STANDARD TESTS IN COUNSELING ENGINEERING STUDENTS IN COLLEGE[1]

WALTER R. McCLANAHAN AND DAVID H. MORGAN

Colorado Agricultural and Mechanical College

For a number of years the failure of students in college has been recognized as a problem for which the college should take some responsibility. The student loses the time, effort, and money which he has expended as well as his own self-respect. The college loses the time, effort, and money devoted to the education of one who has failed to attain the desired goal. While failure may result from a number of factors, it is now recognized that many potential failures in certain lines of work may be eliminated through the use of valid aptitude tests.

The literature contains many studies, including a number of excellent summaries[8,12,31,34,40] reporting the relationship between various predictive criteria and college grades. In general, measures of high-school achievement and general aptitude tests have most frequently been used.

Several studies[1,2,3,13,15,26,28,36,39] of the factors related to the success or failure of students in engineering have been made in order to discover means of reducing student mortality in engineering college courses. However, as pointed out by a number of writers[4,7,16,37] there is so much variation between institutions and between colleges or divisions within the same institution that generalizations cannot be made until sufficient research has revealed fundamental principles that are applicable throughout the country. Until such time the application of research completed in one situation to a different situation is valid only to the degree in which the two are similar. The purpose of this study, therefore, was to investigate the predictive value of the various tests regularly administered to new students at Colorado Agriculture and Mechanical College for Students enrolled in engineering. In order to solve the problem, answers to the following questions were sought:

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[1] Submitted as partial fulfillment of the requirements for the Master's degree and published by special permission of the Dean of the Graduate School, Colorado A. and M. College.

1) What is the relationship between grades achieved during the freshman year and graduation in the Engineering Division?

2) What relationship is there between scores achieved by freshman students on various psychological tests and grades achieved during the freshmen year in the Engineering Division?

3) What is the relationship between high-school academic achievement expressed in terms of rank in the high-school graduating class and grades achieved during the freshman year in the Engineering Division?

4) What factors or combination of the factors considered are of optimum value in forecasting grade-point average for the freshman year in the Engineering Division?

5) What weights should be assigned to the retained factors to secure optimum prediction of the student's grade-point average during the freshman year in the Engineering Division?

6) What system can be devised for making the findings useable by counselors in high schools and colleges?

This study was limited to the students admitted as freshmen during the first semester of 1936–37, the Fall and Winter quarters of 1945–46, and the Fall quarter of 1946–47.

The predictive measures used were the American Council on Education Psychological Examination for College Freshmen, 1943 Edition; the Iowa Placement Examination Chemistry Aptitude, Series CA-2, Form M; the American Council on Education Coöperative English Test, Form PM; and the Nelson-Denny Reading Test for Colleges and Senior High Schools, Form A; and high-school rank.

The grade-point average attained by each student during his freshman year was selected as the criterion of freshman academic success in the Engineering Division. The freshman grade-point average was computed as follows:

1) Weights were assigned each letter grade, so that an A equaled 4, a B equaled 3, a C equaled 2, a D equaled 1, and an F equaled 0. WF (withdrawal failure) and E (incomplete) were counted as F. WP (withdrawal passing) was disregarded.

2) Grade points were computed by multiplying the number of credits by the weight assigned the letter grade.

3) The freshman grade-point average for the year was computed by dividing the sum of the total grade points earned during the freshman year by the total number of credits.

SAMPLES STUDIED

Data from members of the freshman class entering in September, 1936 and 1937, were studied in order to select a critical freshman grade-point average which would be indicative of the lowest grade-point average which a student might acquire during his freshman year and still expect to graduate from the Engineering Division. The 1936 and 1937 samples contained one hundred fourteen engineering freshman students, forty of whom graduated from the Engineering Division.

Data from members of the freshman class entering the Engineering Division in September, 1945, were studied to determine the relationships between data furnished advisers by the office of student affairs and freshman-year grade-point average. Fifty-seven engineering freshmen constituted the 1945 sample. The number of students for whom the variables (high-school rank, and the A.C.E., English, Chemistry and Reading tests and combinations of these variable) were available ranged from 31 to 55.

Data on members of the engineering freshman class of 1946 were studied to determine the efficiency of a formula derived from the 1945 sample for predicting grade-point averages of succeeding freshman classes. One hundred engineering freshmen were obtained for the 1946 sample by selecting every third name from the roll of students in alphabetical order. A.C.E., English, Reading, and Chemistry test scores and high-school rank were all available for every member of this sample.

STATISTICAL METHODS

Statistical methods used in studying the relationship of various variables with first-year grade-point averages for the 1945 sample involved the following steps:

1) Zero-order correlations were computed to measure the statistical relationship between each of the variables and first-year grade-point averages. These zero-order correlations were computed by using the Pearson product-moment method.

2) Intercorrelations were calculated between each of the variables and every other variable to determine the extent to which the various variables measured common factors.

3) Using these data, multiple-correlation coefficients were computed to obtain the relationship between various combinations of variables and grade-point averages.

4) With the most efficient combination of variables, a regression equation was calculated.

5) The standard error of estimate was used to gauge the accuracy of predicting grade-point averages from the regression equation.

Using the regression equation, predicted grade-point averages were calculated for each member of the 1945 and 1946 samples. Zero-order coefficients of correlation were calculated in order to determine the relationship between predicted and achieved grades for both the 1945 and the 1946 samples.

FINDINGS

Zero-order coefficients of correlation calculated between each of the five measures of aptitude and first-year grade-point average (Variable 1), were found to be as follows:

1) $r12 = .583$ (Coöperative English, Variable 2)
2) $r13 = .652$ (Chemistry Aptitude, Variable 3)
3) $r14 = .495$ (Reading Test, Variable 4)
4) $r15 = .648$ (A.C.E., Variable 5)
5) $r16 = .359$ (High-school rank, Variable 6)

Multiple coefficients of correlation[1] were calculated for the five variables in various combinations with one another. The combinations of variables which produced the highest multiple coefficient of correlation were as follows:

1) $r1.23456 = .848$
2) $r1.2345 = .848$
3) $r1.234 = .846$
4) $r1.23 = .814$

For practical purposes, the combination of the variables, English and Chemistry test scores, was considered to be the most

[1] For complete statistical results see McClanahan.[30]

economical and feasible battery to use in counseling and, therefore, was used in the calculation of the following regression equation:

Grade-point average = $.008X_2 + .016X_3 - .16$, where X_2 = English raw score, and X_3 = Chemistry raw score.

The standard error of estimate for the grade-point average was found to be .45.

PREDICTIVE EFFICIENCY FOR SUCCEEDING GROUPS

The coefficient of correlation between predicted first-year grade-point averages calculated from the regression equation and achieved first-quarter grade-point averages of individuals of the 1946 sample was found to be .657. This was slightly lower than the coefficient of correlation of .676 calculated between predicted first-year grade-point averages, using the regression equation, and the achieved first-year grade-point averages of the 1945 sample. Closer agreement between the coefficients of correlation should be expected if first-year achieved grades instead of first-quarter achieved grades were correlated with predicted first-year grades in the 1946 sample; however, the agreement between these coefficients of correlation was sufficiently close to warrant the assumption that the regression equation computed from the 1945 sample can be used to predict grades in the 1946 sample.

In order to check the efficiency of the regression equation for predicting the achieved grade-point averages of a succeeding freshman class, a comparison was made between the theoretical probability of students in the 1946 sample achieving grades equal to or greater than grades predicted by use of the regression equation and the empirical probability that students in the 1946 sample would obtain grades equal to or greater than grades predicted from the regression equation.

Theoretical probability was computed by use of the standard error of estimate of predicted grades, and empirical probability was found by computing the percentages of students in the 1946 sample who achieved first-quarter grades equal to or greater than their predicted first-year grades. Table 1, prepared by the method described by Freeman and Johnson[16] (1–65), shows the empirical probability of a student in the 1946 sample with a predicted first-year grade-point average equal to or better than 2.00 as forty chances in one hundred of obtaining a first-quarter grade

equal to or greater than a first-year grade-point average of 2.00. The theoretical probability of a student achieving a first-year grade-point average equal to or greater than a predicted first-year grade-point average of 2.00 is fifty chances in one.

TABLE 1.—CHANCES IN ONE HUNDRED THAT A FRESHMAN IN THE DIVISION OF ENGINEERING WITH A PARTICULAR PREDICTED SCORE (*W*) WILL EARN A GRADE EQUAL TO OR ABOVE DIFFERENT SPECIFIED GRADE LEVELS

Predicted G.P.A. (*W*)	Chances in 100 of earning a grade equal to or above		
	D = 1.00	*C* = 2.00	*B* = 3.00
3.50 and above	99	96	95
3.25 to 3.49	99	96	95
3.00 to 3.24	95	94	85
2.75 to 2.99	90	88	80
2.50 to 2.74	82	76	50
2.25 to 2.49	70	60	35
2.00 to 2.24	51	40	20
1.75 to 1.99	31	13	0
1.50 to 1.74	16	5	0
1.25 to 1.49	10	2	0
1.00 to 1.24	2	0	0
.75 to .99	2	0	0
.50 to .74	0	0	0
below .50	0	0	0

There was considerable discrepancy between the empirical and theoretical probabilities of achieved grades equaling or excelling predicted grades. This discrepancy was greatest at the extreme grade levels and was least for grades about the 2.00 grade-point average level. The number of cases falling in the extreme grade intervals of the limited group of one hundred students in the 1946 sample was few, and any empirical probability based on percentages of those achieving grades equal to or above the grade

intervals containing such a few cases should be expected to deviate considerably from the theoretical probability.

NOMOGRAPHIC CHART

Advisers are often undecided as to whether they should encourage an aspirant to the engineering course to matriculate in the engineering division during the freshman year. By use of the test scores on the Chemistry and English tests and the predictive chart, the adviser may determine the probability of the student obtaining during his freshman year a grade-point average equal to or greater than any specific grade level. Where the student's predicted grade-point average falls below the critical grade-point average of 2.00, his chances of graduating from the engineering division are against him, and it may be advisable to refer him to the office of student affairs for diagnosis and vocational counseling before he undertakes any definite course of action. Such a procedure, if adopted by advisers, should reduce mortality among engineering freshmen without preventing qualified aspirants from trying out in the engineering course.

A nomographic predictive chart for estimating freshman grades of engineering students, prepared in connection with this study, is not presented here since with its reduction to type-page size the figures would not be legible. If faculty advisers are provided with a copy of the nomographic predictive chart they should find it helpful in the following respects:

1) To determine those students who might be advised to take a limited program.

2) To recommend to the office of student affairs for clinical counseling cases of serious discrepancy between achievement and ability.

3) To recommend to the office of student affairs for clinical counseling those students whose measured abilities indicate possible lack of capacity to succeed in the engineering division.

SUMMARY AND CONCLUSIONS

The best single predictor of first-year engineering grades among the variables was the Chemistry test, followed by the A.C.E., the English test, and the Reading test. Intercorrelations indicated that the English test, the A.C.E., and the Reading test measure

much the same thing and that of the three, the English test is the best test to combine with the Chemistry test. The low correlation of high-school rank with first year grades indicated it to be the poorest predictor.

Multiple coefficients of correlations indicated that the Chemistry and English tests were the best and most economical battery for predicting first-year grades. The addition of other variables did not increase the multiple coefficient sufficiently to justify the additional work involved.

The regression equation and standard error of estimate may be useful counseling devices when graphically represented on a nomographic chart to facilitate their use by advisers. By using the nomographic chart on which a critical score has been designated, advisers should be able to estimate the probability that a student will succeed in the freshman year of engineering and should be able to select students whose chances of graduating from the engineering division are small and who are, therefore, possibly in need of further clinical counseling.

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BOOK REVIEWS

ROGER G. BARKER, BEATRICE A. WRIGHT, AND MOLLIE R. GONICK. *Adjustment to Physical Handicap and Illness: A Survey of the Social Psychology of Physique and Disability.* New York: Social Science Research Council (Bulletin 55), 1946, pp. 372.

In recent years, there has been a great increase in organized social efforts to provide education and guidance for physically disabled persons. Somatopsychological research, as a consequence, has practical as well as theoretical importance. Of great value, therefore, would be an appraisal of the literature of the social and psychological significance of disability, particularly when explained in terms of relevant concepts in the light of which known facts can be described and explained. In an effort to satisfy this need, the authors found themselves carefully reviewing several hundred studies. They found much of the writing on the subject still on the folklore level, and much of the more reliable material fragmentary.

The findings are reported in six chapters. Topics include: somatopsychological aspects of normal variations in physique, significance in crippling, psychology of tubercular, significance of impaired hearing, social psychology of acute illness, and employment of the disabled. Research summaries of significant studies given include an expression of the problem and subject, methods used, conclusions found. The bibliographies of literature on somatopsychological significance of physique are presented in terms of the following twelve topics: normal variation, orthopedic impairment, tuberculosis, impaired hearing, acute illness, employment, visual disability, cardiac disability, diabetes mellitus, cosmetic defect, rheumatism, cancer. A very impressive and imposing list of references are given. Age, race and sex are omitted from the consideration of disabilities reviewed because it was the impression of the writers that this literature has been sufficiently reviewed in recent years and is easily available. Speech defect, too, has been omitted because this is a well documented field. Leprosy has been excluded since it is a minor problem in western countries. Bibliographical sources investigated include the literature of medicine, psychology, education, sociology, occupational therapy, vocational rehabilitation, voca-

tional placement, and labor relations. To the largest extent the treatment has been confined to the cultural conditions existing in the United States and Britain. Publications from other countries have been included only if the significance is clearly not limited by local social conditions.

In defining the problems of a relation between physique and behavior, Dr. Barker and his associates considered several kinds of causal relations between them. This gives them a frame of reference for everything they have searched, investigated and reported. Physical handicaps, their studies reveal, serve as a never ending source of frustration. Styles of adjustment to frustration, adjustment and readjustment made to frustration, are considered at some length in this volume. Their general conclusions concerning handicapped people they summarize as follows: (1) Different types of physical deviation are not distinguished by clearly marked personality manifestations. (2) Physically handicapped women exhibit hyper-sexuality approaching asexuality in some cases. (3) They are emotionally immature, showing great family dependence. (4) There is no evidence that auto-erotic or homo-erotic practices increase as a result of hetero-sexual frustration. (5) Age at the onset, severity and stability of disability, and intelligence of subjects are related to kind and effectiveness of adjustment. Students of placement and guidance will find the final chapter on the employment of disabled a very serviceable one. It is comprehensive and, in some ways, one of the most significant for rehabilitation programs and related efforts. It gives relevant and concise information concerning differences between handicapped and non-handicapped in such factors as absences, accidents, increase of earnings, production, costs of special placement, and related information. Various specific suggestions for improving or attempting to solve the employment problem of the handicapped are given. The final conclusion is that for the good of both the disabled employee and the employer, the rules of the industrial game should be changed to include the disabled worker in the labor force as a matter of course. They consider two ways by which this might be done: FEPC is one of them; and the more adequate one, in the opinion of the writers, is the one similar to the method used in England. Under the Disabled Persons (Employment) Act, enacted in the Spring of 1944, there was created in Britain an official register of

disabled persons from which employers are required to hire a designated quota of their labor force. Whether this could and would work in the United States is obviously questionable.

All in all, this monograph, which is sponsored by the Committee on Social Adjustment of the Social Science Research Council, is extremely well done and serves a very useful purpose. Dr. Barker and his associates are to be congratulated on the thorough and competent job they have done in both the covering of the literature and the appraisal of it, as well as organizing the presentation of the material to serve as aids to work programs and research purposes.

H. MELTZER
Psychological Service Center
St. Louis, Missouri

C. E. M. JOAD. *How Our Minds Work.* New York: Philosophical Library, 1947, pp. 116.

Mind as distinct from the body is set in opposition with mind as an aspect of the body. According to the author, psychology, unlike other sciences, is concerned less with facts than with theories, and that psychology very largely belongs to the province of speculation. After an inadequate and one-sided presentation of behavioristic psychology as representing an objectionable materialist position, the author presents his argument for mind as distinct from body and brain. Mind is something that is immaterial, it is in some sense independent of the brain. The relation of mind and body is shown by "mind influences body and body mind at every moment of our waking life."

This book belongs to Eighteenth Century philosophy rather than to the contemporary period. It makes no worth-while contribution. It can only appeal to minds that are one-sided and completely closed to consideration of contributions of Twentieth Century psychology.

MILES A. TINKER
University of Minnesota

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